

WHAT IS CLAIMED IS:

1 1. A video-based animal behavior analysis system, comprising:
2 a computer configured to determine a position and shape of an animal from video
3 images and characterize activity of said animal based on analysis of changes in said
4 position and said shape over time.

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1 2. The system of claim 1, further comprising:
2 a video camera and a video digitization unit coupled to said computer for capturing
3 said video images and converting said video images from analog to digital format.

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1 3. The system of claim 2, further comprising:
1 an animal identification, segregation, and tracking module receiving said
2 video images.

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1 4. The system of claim 3, wherein said computer further includes a behavior
2 identification module for characterizing activity of said animal, said behavior
3 identification module being coupled to said animal identification, segregation, and
4 tracking module.

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1 5. The system of claim 4, wherein said computer further includes a standard
2 animal behavior storage module that stores information about known behavior of a
3 predetermined standard animal for comparing the activity of said animal, said

4 standard animal behavior storage module being coupled to said behavior identification
5 module.

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1 6. The system of claim 1, wherein said animal is a mouse.

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1 7. The system of claim 1, wherein said animal is a rat.

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1 8. A method of determining and characterizing activity of an animal using
2 computer processing of video images, comprising the steps of:
3 detecting an animal in said video images;
4 tracking changes to said animal over a plurality of said video images;
5 identifying and classifying said changes to said animal; and
6 characterizing said activity of said animal based on comparison to pre-trained models
7 or rules of such activity or based on calculation of behavioral parameters of
8 behavioral processes and behavioral events..

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1 9. The method of claim 8, wherein said detecting an animal includes using a
2 background subtraction method comprising the steps of:
3 apply a adaptive or constant threshold on the difference values between a current
4 image and a background so as to determine a broad region of interest;
5 post-process the various pixels in said region of interest to obtain said animal using
6 various morphological and area refinement techniques; and
7 refine contours of said animal image by smoothing.

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1 10. The method of claim 8, wherein said step of identifying and classifying
2 changes to said animal includes using statistical shape information selected from the
3 group consisting of:
4 area of the animal;
5 centroid position of the animal;
6 bounding box and its aspect ratio of the animal;
7 eccentricity of the animal; and
8 a directional orientation of the animal relative to an axis as generated with a Principal
9 Component Analysis.

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1 11. The method of claim 8, wherein said steps are also performed in night
2 conditions by using red light to simulate such night conditions, or by using infra-red
3 cameras to capture the images with no light;

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1 12. The method of claim 8, wherein said steps are also performed with a plurality
2 of cages or arenas, each of which contains a single animal;

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1 13. The method of claim 8, wherein said step of characterizing said activity of said
2 animal based on calculation of behavior parameters of behavioral processes and
3 behavioral events includes the steps of:
4 locating feature points and segments of the said animal;
5 detecting behavior events by comparing animal feature against predefined rules; and

6 detecting behavior parameters of behavioral processes.

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1 14. The method of claim 13, wherein said step of locating feature points and
2 segments of the said animal includes the step of detecting body parts of the animal;

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1 15. The method of claim 14, wherein said body parts include the head;

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1 16. The method of claim 14, wherein said body parts include the tail;

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2 17. The method of claim 14, wherein said body parts include the waist;

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4 18. The method of claim 14, wherein said body parts include the fore body;

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1 19. The method of claim 14, wherein said body parts include the hind body;

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1 20. The method of claim 8, wherein said video images include images captured of
2 various animal behavioral analysis apparatuses and said tracking, identifying and
3 characterizing of activities is performed on those animal behavioral analysis
4 apparatuses.

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1 21. The method of claim 20, wherein said various animal behavioral analysis
2 apparatuses include home cage, a cage looking like a shoebox used for housing
3 animals.

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1 22. The method of claim 20, wherein said various animal behavioral analysis
2 apparatuses include open field, in various shapes such as circular, square, or
3 rectangular.

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1 23. The method of claim 20, wherein said various animal behavioral analysis
2 apparatuses include Water Maze, made of a circular pool filled with water and a
3 hidden clear or white Plexiglas platform.

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1 24. The method of claim 20, wherein said various animal behavioral analysis
2 apparatuses include Y-maze (three-sided runway, where one arm can deliver electrical
3 foot-shock through its floor grid), T-maze (Runways are in the shape of T; its sides
4 are made of black Plexiglas or wood; its floor is metal mesh.), and Radial arm maze
5 (comprised of 8 or 12 arms, radiating from a central start box, made of Plexiglas or
6 wood).

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1 25. The method of claim 20, wherein said various animal behavioral analysis
2 apparatuses include zero maze, made of brightly lit, open areas alternating with dark,
3 covered areas, comprising the annulus of an elevated circular runway.

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1 26. The method of claim 20, wherein said various animal behavioral analysis
2 apparatuses include Elevated Plus maze, comprising of four narrow runways, two
3 well lit and open, and two alternating enclosed with walls and dark, and a center box
4 where the animal is placed initially.

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1 27. The method of claim 20, wherein said various animal behavioral analysis
2 apparatuses include Object Recognition, where multiple objects of different shapes
3 and colors are placed in an open field.

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1 28. The method of claim 20, wherein said various animal behavioral analysis
2 apparatuses include cued or conditioned fear chambers used for freezing

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1 29. The method of claim 20, wherein said various animal behavioral analysis
2 apparatuses includes using an unified framework, called “virtual apparatus”, which
3 uses a graphic tools to simulate various types of apparatuses.

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1 30. The method of claim 20, wherein said various animal behavioral analysis
2 apparatuses includes “virtual zones”, which are created with graphic tools provided in
3 the system to simulate various types of dividing zones within the apparatuses.

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1 31. The method of claim 13, wherein said detection of behavioral events includes
2 turning ratio: ratio of path length traveled over number of turns, where number of
3 turns is counted when the animal makes a turn larger than 90 degrees when the animal
4 travels one body length.

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1 32. The method of claim 13, wherein said detection of behavioral events includes
2 sniffing at objects, an event counted when animal’s nose is in contact with an object
3 in a object recognition apparatus

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1 33. The method of claim 13, wherein said detection of behavioral events includes
2 stretch-and-attend: Cautious approach with fore body stretched and lowered followed
3 by the retraction of the fore body.

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1 34. The method of claim 13, wherein said detection of behavioral events includes
2 stay-across-areas: partial incursions into particular zones. For example, the animal
3 might maintain its hind quarters in a closed arm while poking its nose into an open
4 arm.

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1 35. The method of claim 13, wherein said detection of behavioral events includes
2 head dipping, exploratory movement of head/shoulders over the side of the maze.

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1 36. The method of claim 13, wherein said detection of behavior events includes
2 the behavior of freezing, and said freezing behavior is determined by the absence of
3 movement of rodent body for a brief period of time;

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1 37. The method of claim 13, wherein said detection of behavior events includes
2 the behavior of locomoting, and said locomotion behavior is determined by the
3 movement of the rodent around the cage or arena when viewed from the top;

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1 38. The method of claim 13, wherein said detection of behavior events includes
2 the behavior of transgressing from zone to another, and said transgression behavior is

3 detected by the movement of a portion of, or the entire body of the rodent across from
4 one defined zone or area into another defined zone or area;

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1 39. The method of claim 13, wherein said detection of behavior parameters of
2 behavioral processes includes proximity score: calculated by determining the distance
3 of the animal from the goal during each second of the trial and is used as a measure of
4 deviation from the ideal path to the platform once an animal is placed in a water maze
5 setting.

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1 40. The method of claim 13, wherein said detection of behavior parameters of
2 behavioral processes includes heading errors: defined as an instance of swimming
3 away from the VISIBLE platform in a water maze setting.

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1 41. The method of claim 13, wherein said calculation of behavior parameters of
2 behavioral processes includes: instant and average speed of movements, distance
3 traveled, its instant and cumulative body turning angles.